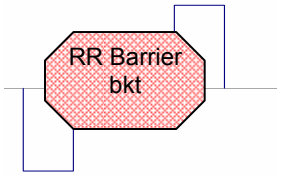


Strip-mining

Chandra Bhat,

Cons Gattuso and P. Joireman

RR Group Meeting

June 14, 2006

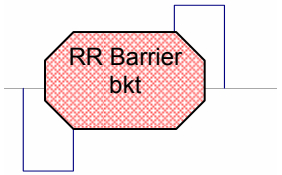
Issue: During the current mining process in the Recycler, i.e., the "Longitudinal Momentum Mining", occasionally the transverse emittances grow and life-time for the beam drops if both stochastic and e-cools are on.

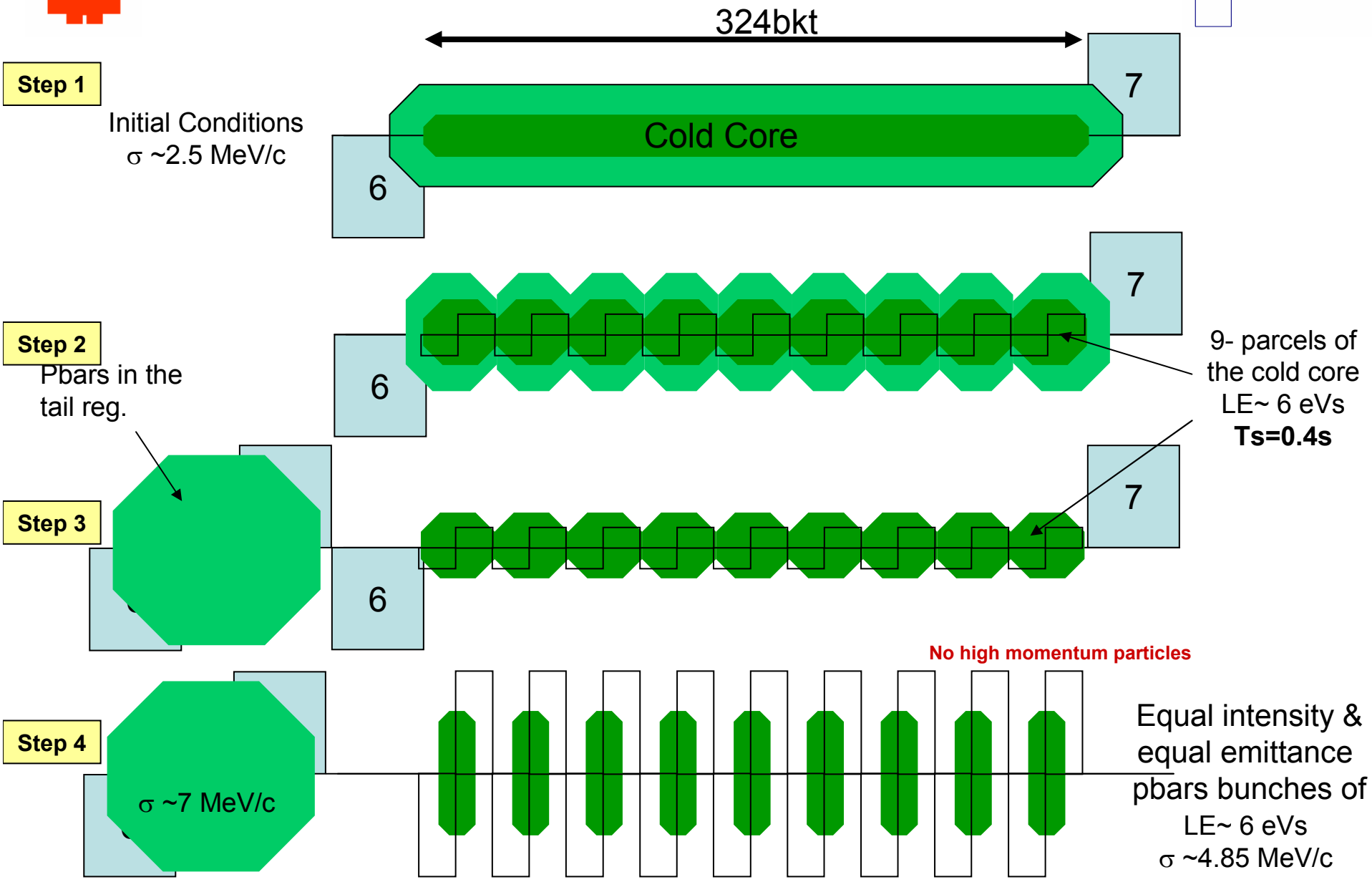
Note: However, this problem did not show-up for the cases with new tune operating points (Alexey and Valeri).

Goals: 1. Improve the mining process to eliminate emittance growth - at the same time retain the quality of pbars for Tev shots good.

2. Develop an ability for pilot shots.

Current Longitudinal Momentum Mining





Status of Emittance during Tevatron Shots

RR Barrier bkt

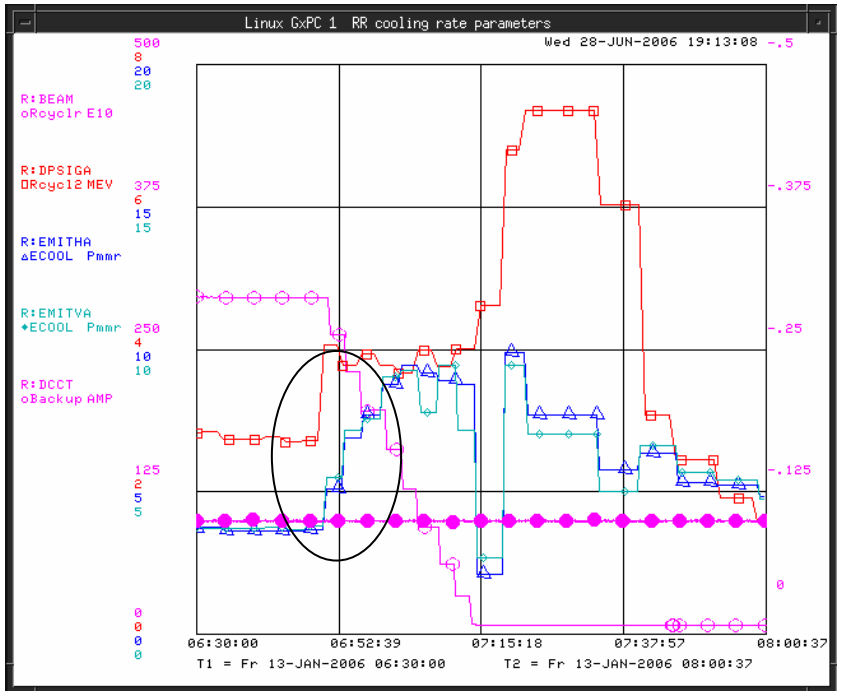
Signature of transverse emittance growth

Growth

Store 4590

Tune= 0.414/418 (H/V)

Luminosity = 150.3E30/cm^2/sec

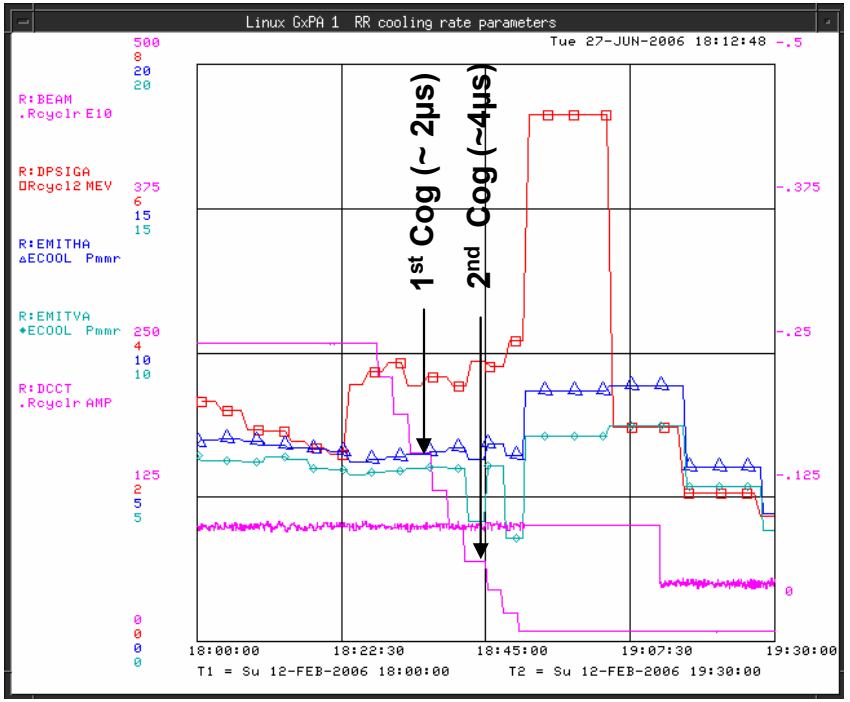


No growth

Store 4639

Tune= 0.451/468 (H/V)

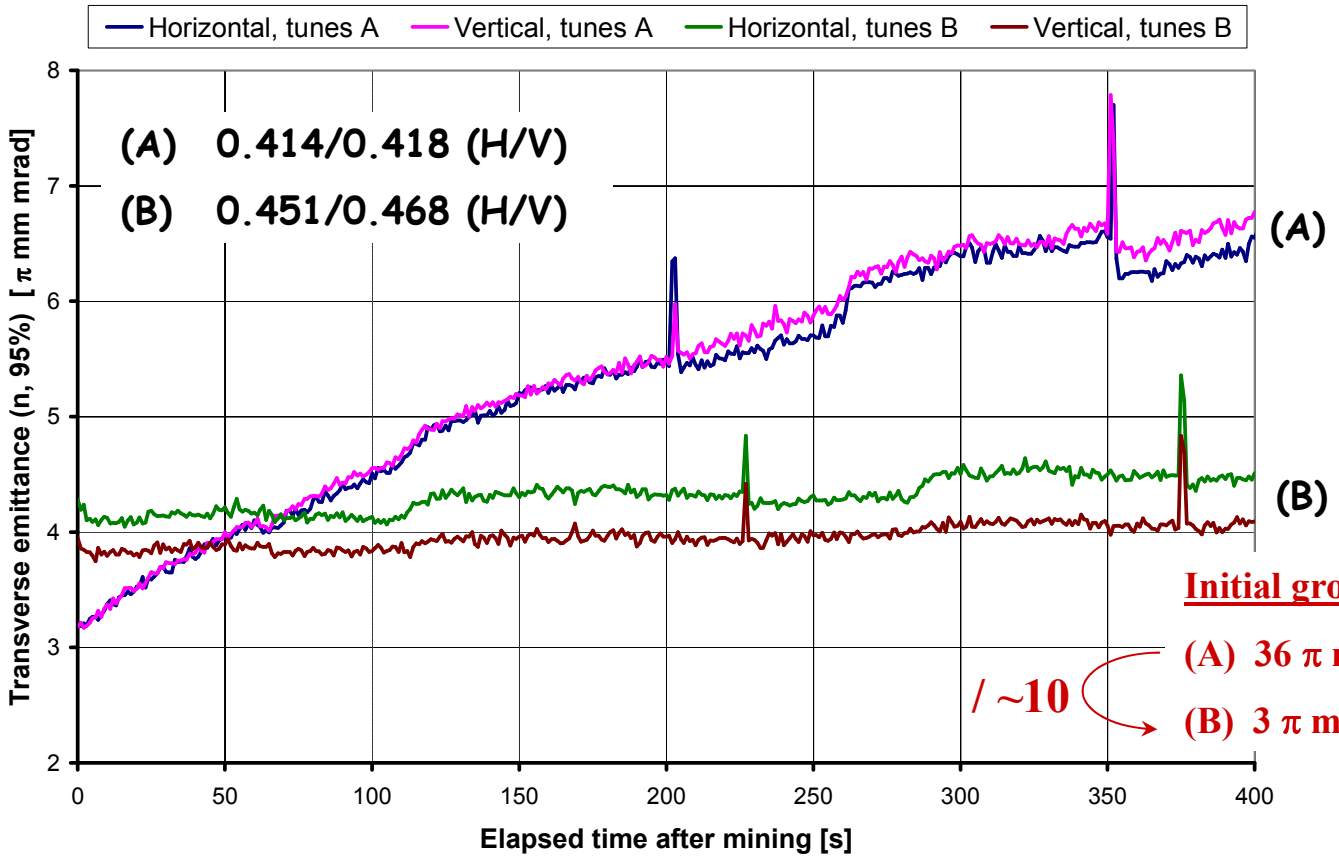
Luminosity = 166.91E30/cm^2/sec



<Emit(H,V) (MI) ~ ?? pi @ 8GeV
~ 2.4 pi @ 150 GeV

Emittance growth during mining

Lionel PROST, et al. - WEAY02



Initial growth rate:

(A) 36 π mm mrad per hour

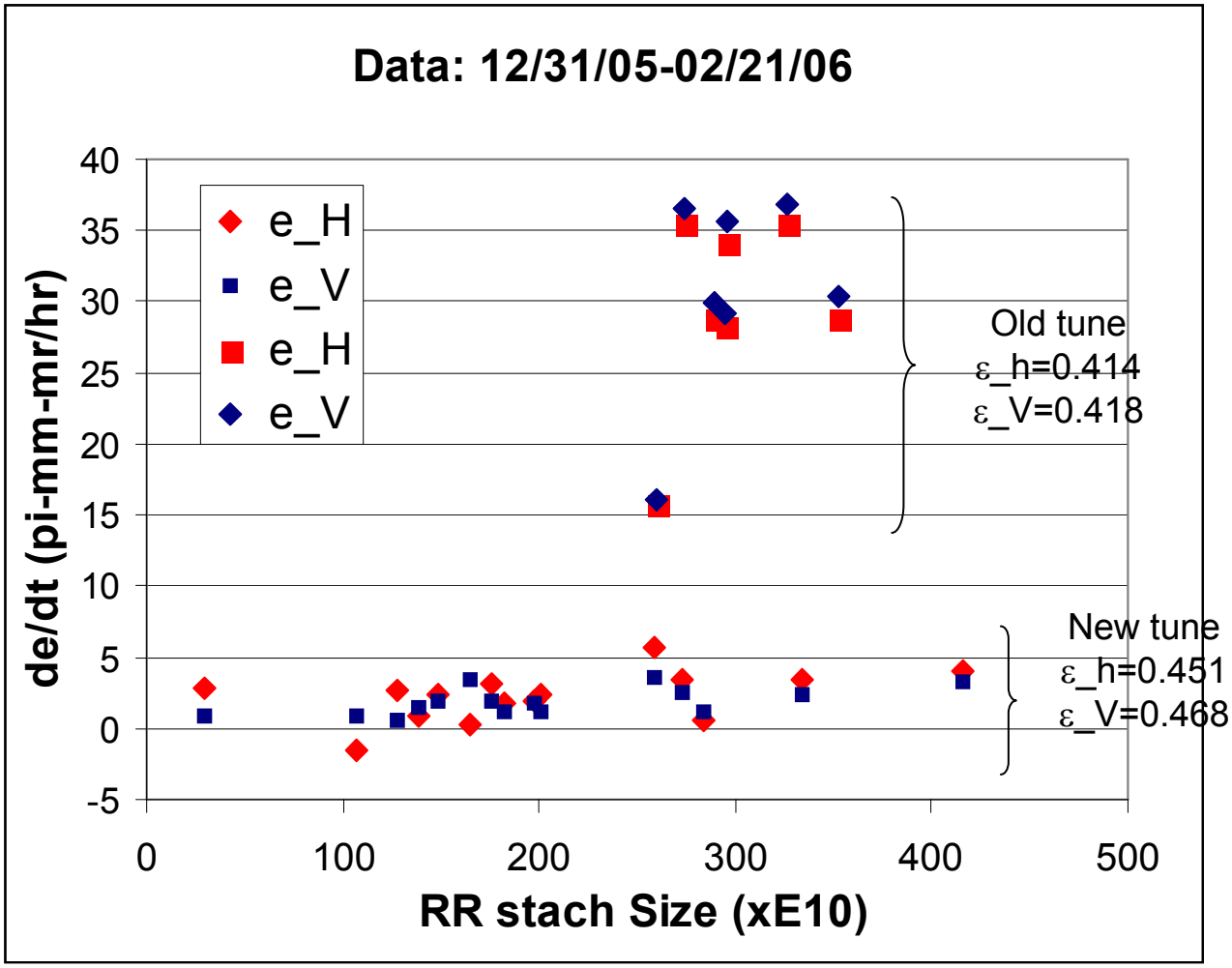
/ ~10

(B) 3 π mm mrad per hour

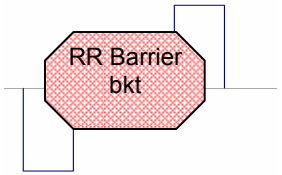
- Emittance growth likely due to a quadrupole instability (see Burov *et al.* , THAW07)
  - Growth rate $\propto \kappa_{xy} I_e I_p$, (κ_{xy} coupling parameter)
  - Increase tune split to reduce κ_{xy}

Data before the shutdown

(from Lionel Prost)



Some Remarks on the Current Mining Procedure



- After the last pbar transfer from the Accumulator cog the stack to the final mining location before the final cooling starts

  →The pulse gap between 6 and 7 = 324 bkts

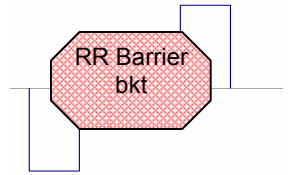
  →The start point of barrier pulse 7 = 32

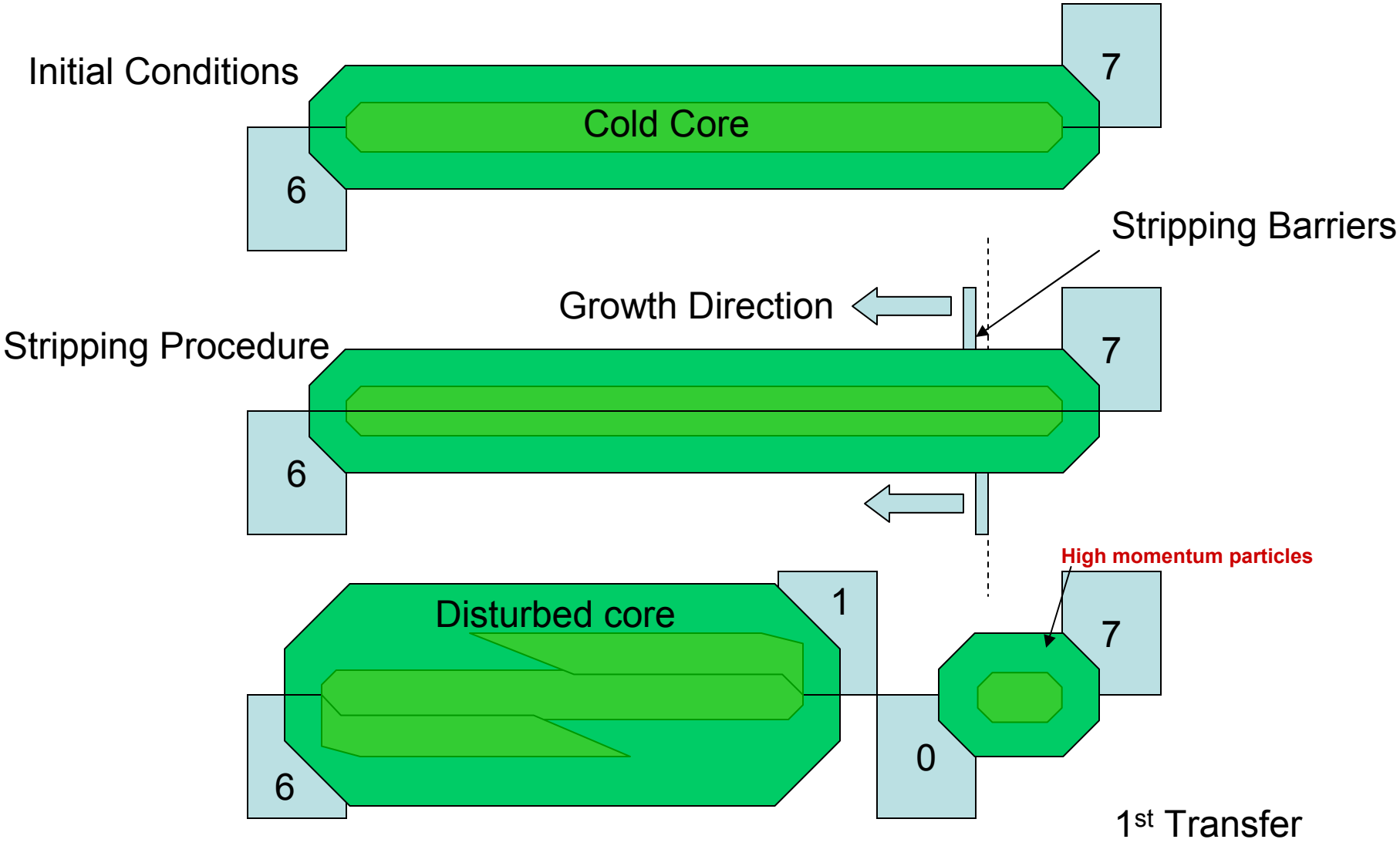
  (Eliminate the steps in R6-state 53 which cogs the cold stack by 92bkts)

  Thus we can eliminate undesirable disturbance of the cold core (and emittance growth) prior to the final mining.

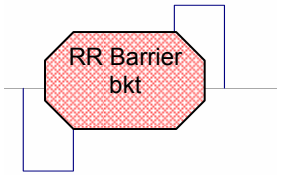
Strip-mining: 1st proposal

Cons Gattuso and P. Joireman

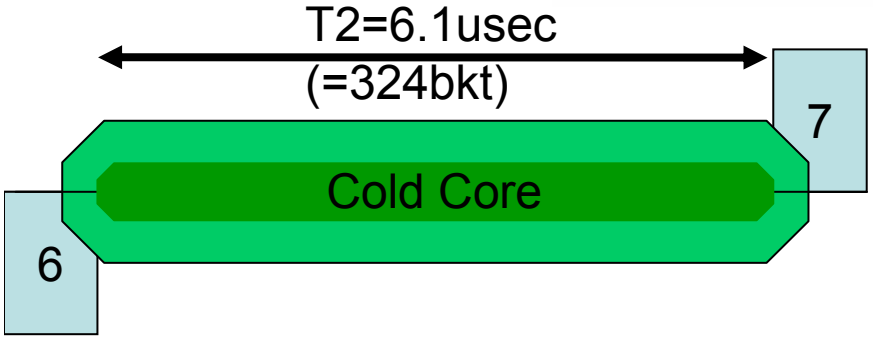


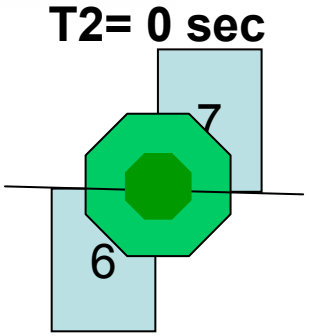


Synchrotron Period and adiabatic process



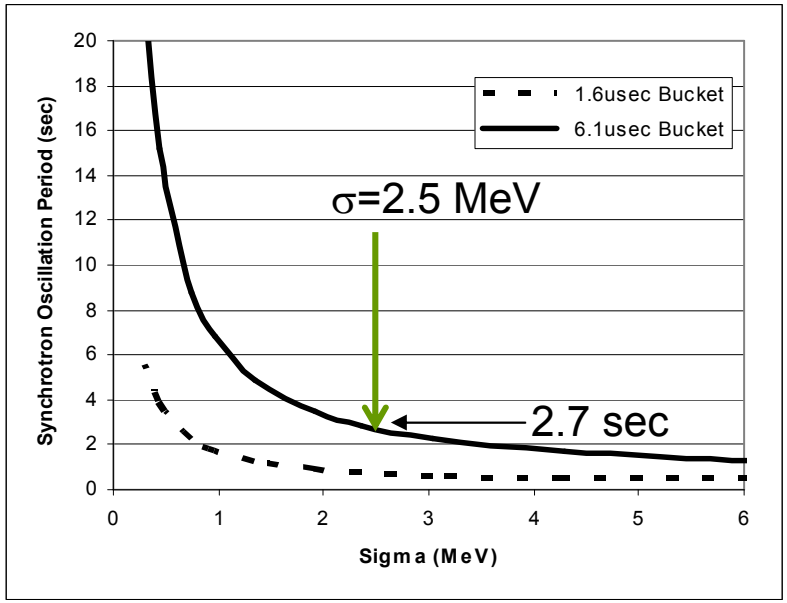
$$T_s = \frac{2T_2}{|\eta|}\frac{\beta^2 E_o}{|\Delta \hat{E}|} + \frac{4|\Delta \hat{E}|T_0}{eV_o}$$

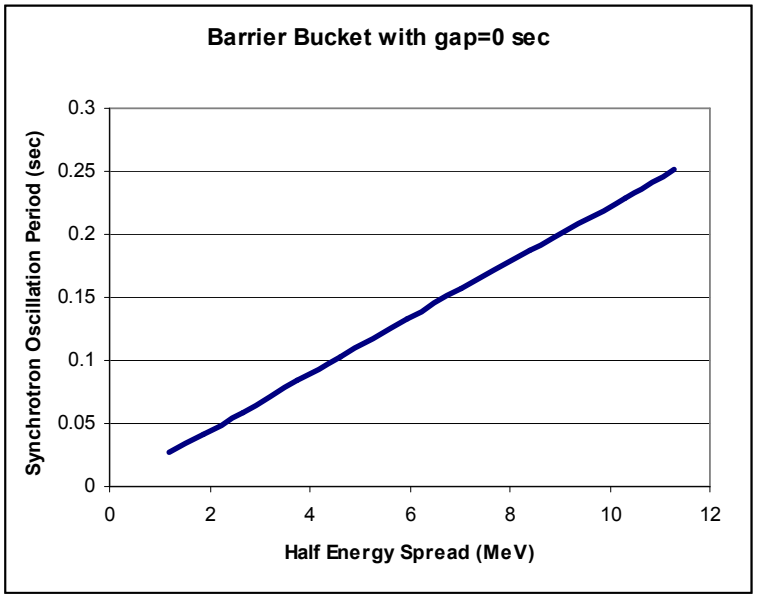




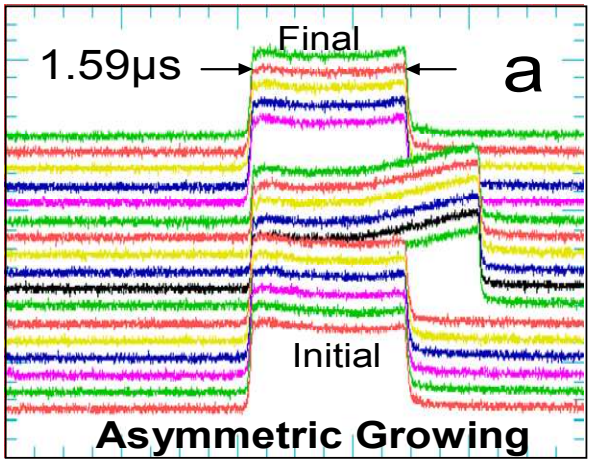
Rule of Thumb

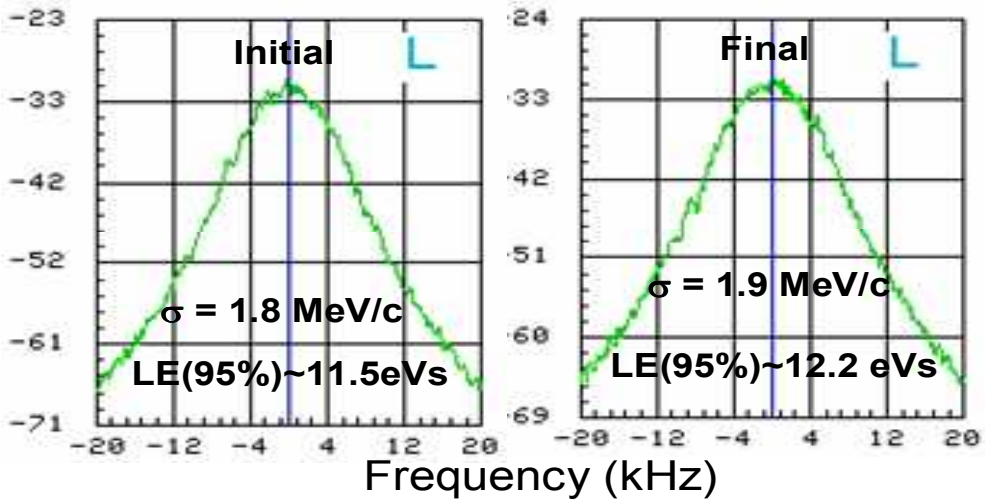
Any rf manipulations is iso-adiabatic, if it is carried out in about 6-8 synchrotron oscillation periods.



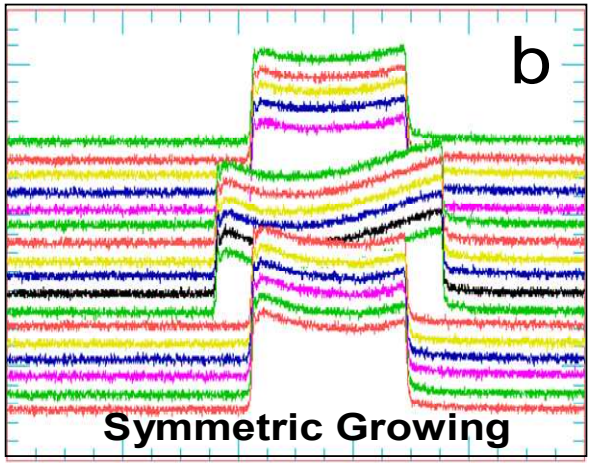


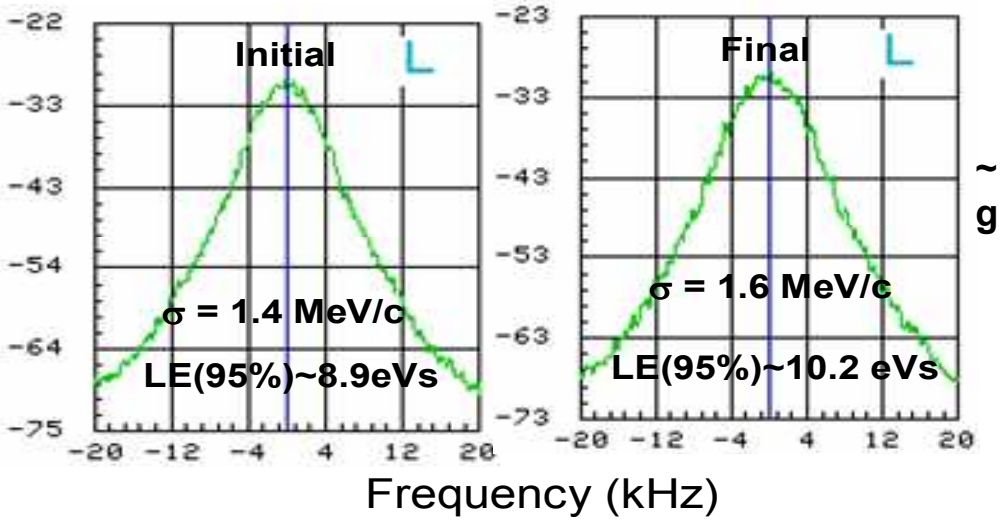
Beam compression studies in the Recycler





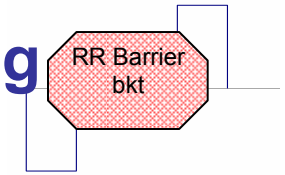
~6% growth



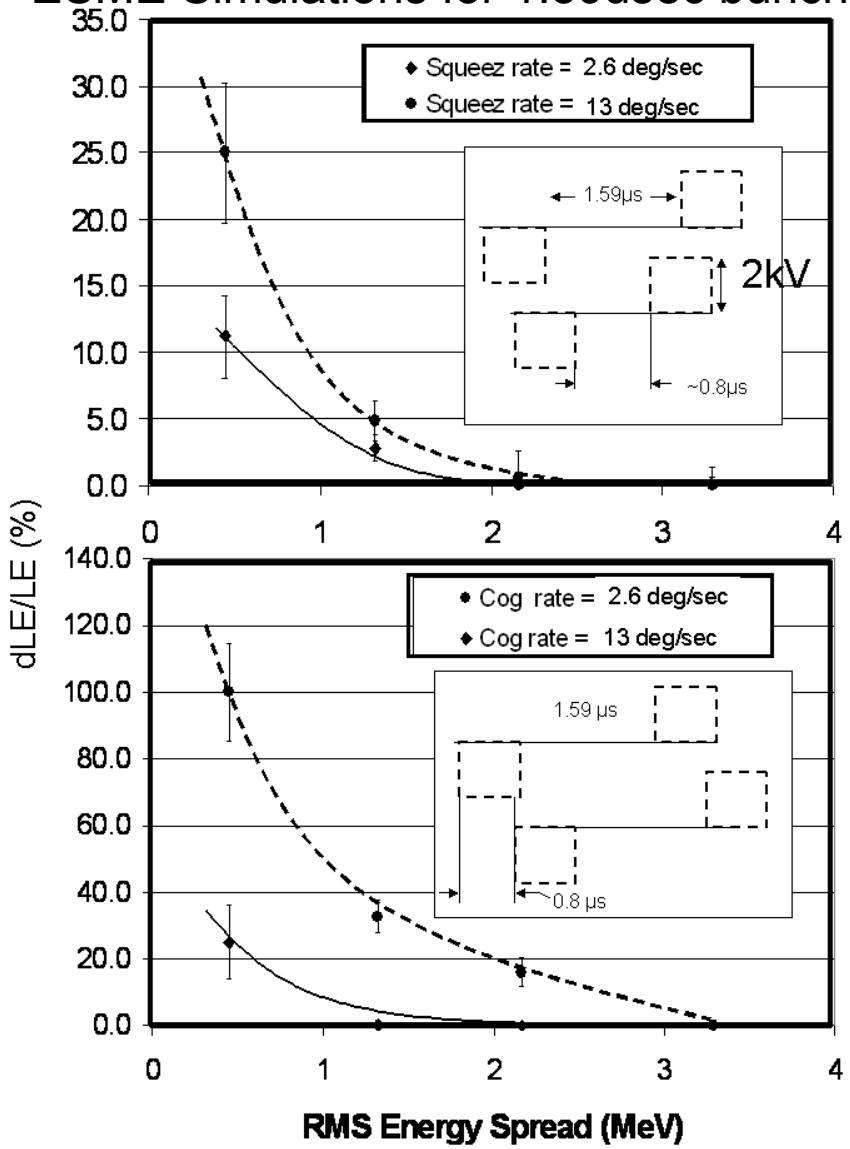


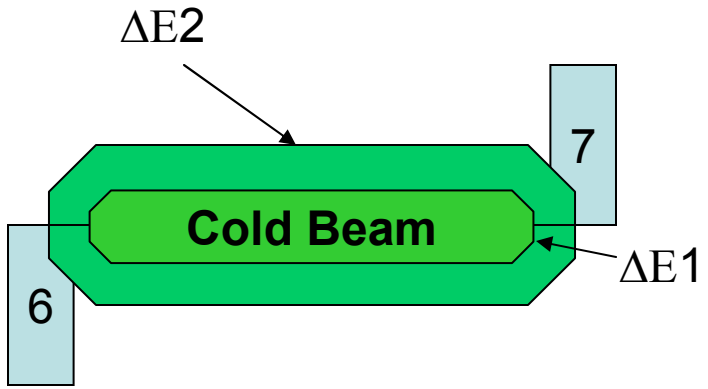
~15% growth

ESME simulations of Compression and Cogging



ESME Simulations for 1.59usec bunch



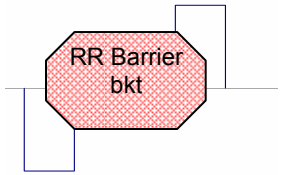


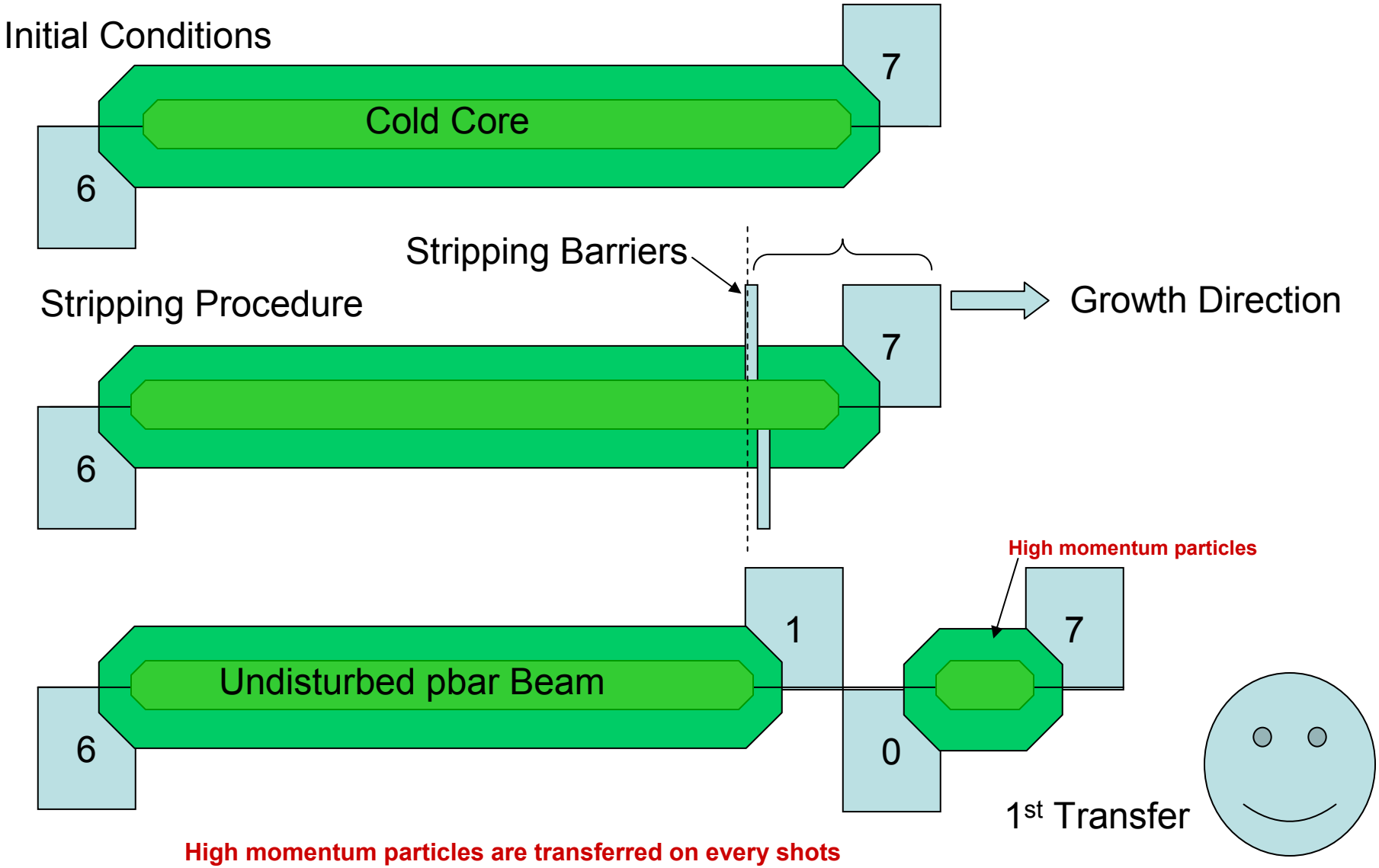
$\Delta E1 < \Delta E2$

Result of beam compression and cogging is that the core particles are affected more than the large ΔE particles

Estimated LE growth of the leftover core is about 17%

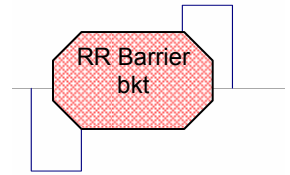
Strip-mining: Improvement



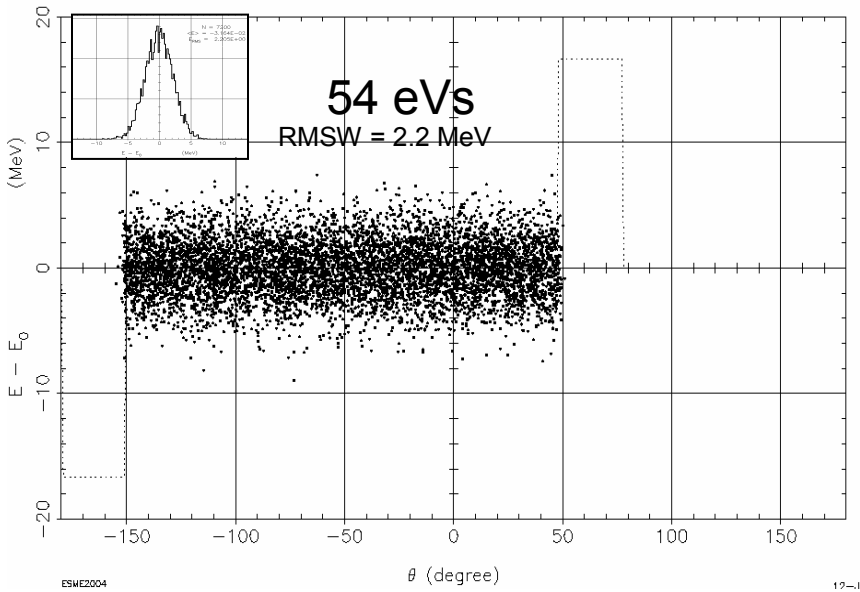


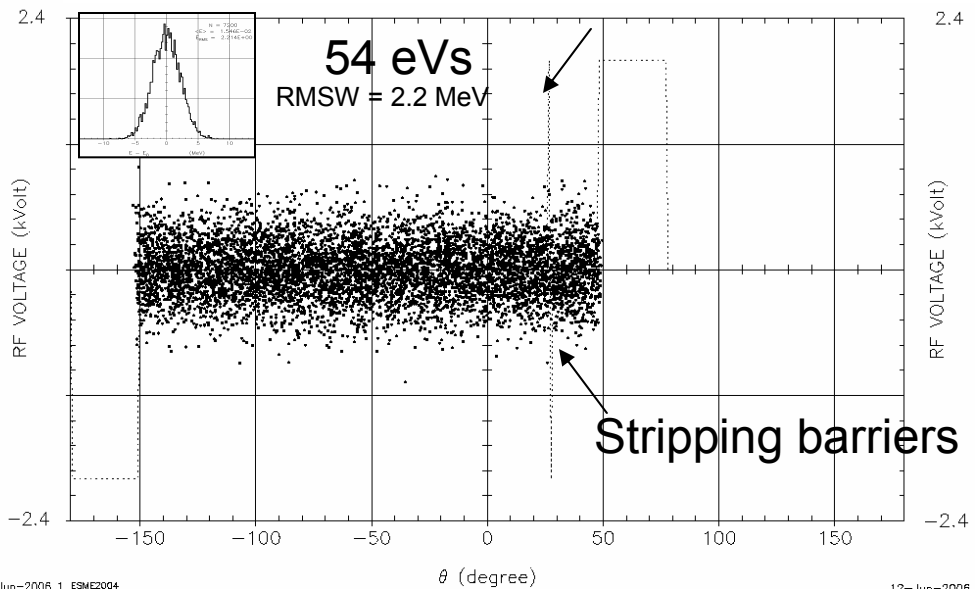
High momentum particles are transferred on every shots

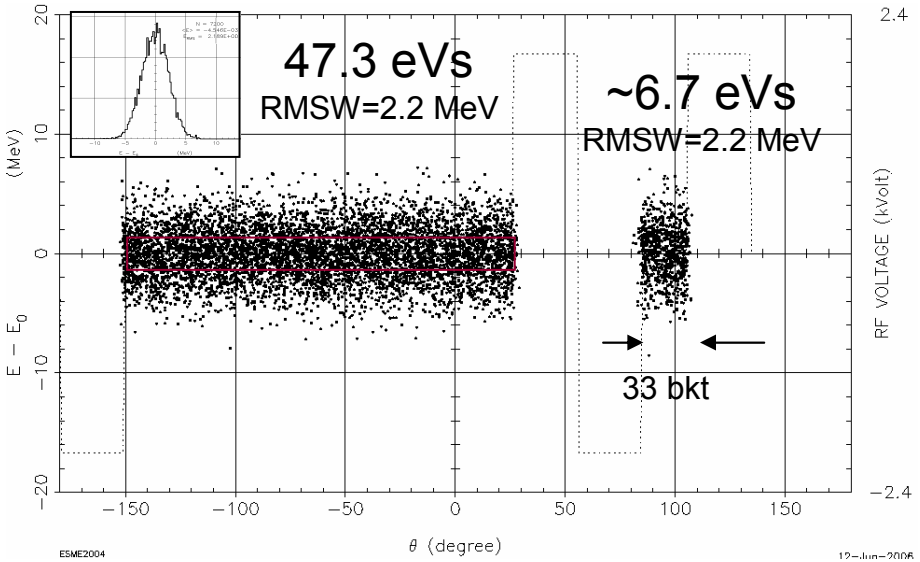
ESME simulations and Findings



With Gaussian Beam in energy coordinates





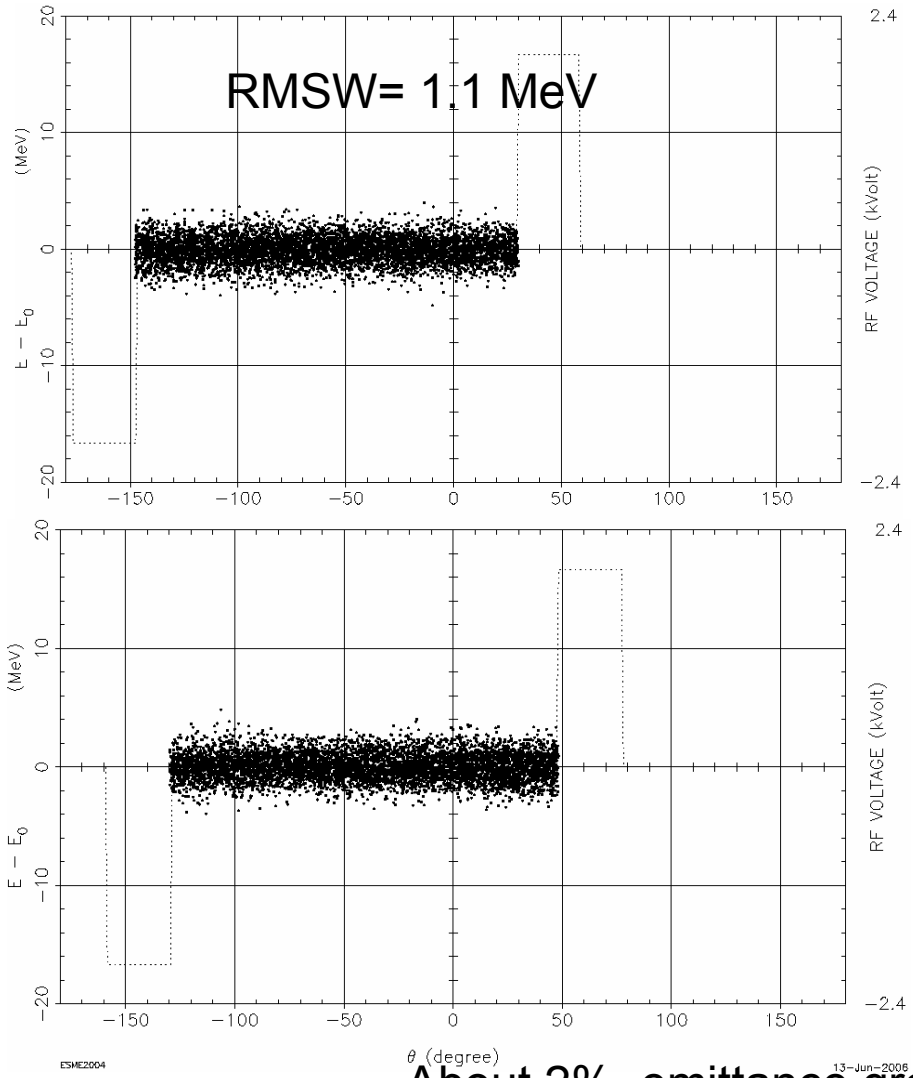


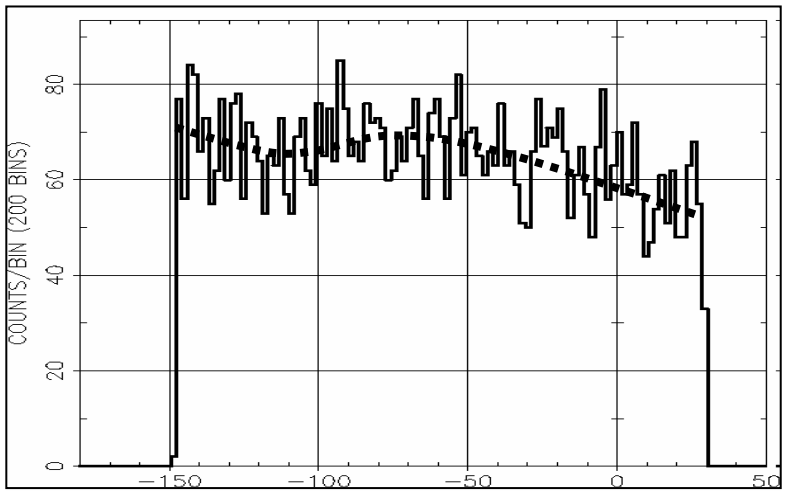
Simulations carried out for the first transfer do not show any observable LE growth

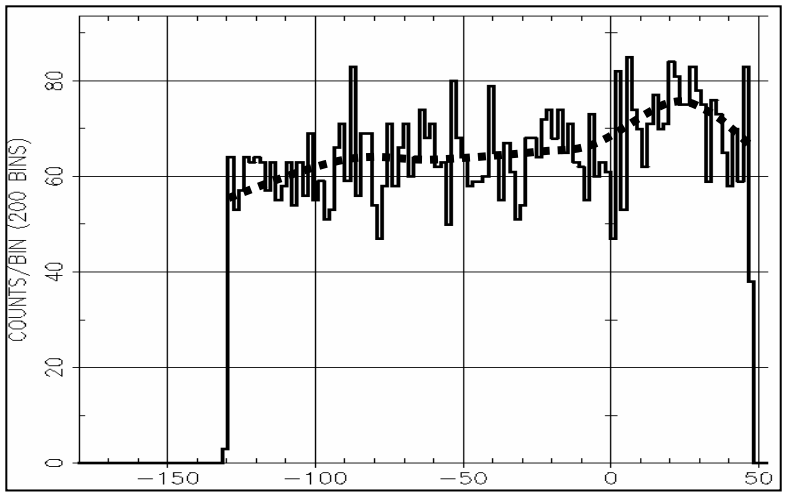
However, during cogging the core does the following

RMSW=1.1 MeV Core during Cogging?

RR Barrier bkt

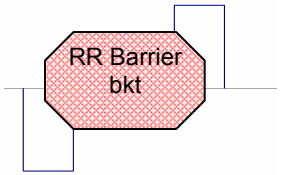






About 2% emittance growth on the first transfer

Some Remarks



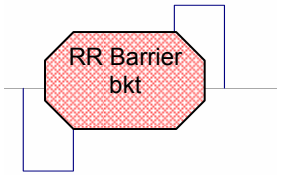
- Strip-mining, in this form, can not select low emittance region of the phase-space, unlike the "Longitudinal Momentum Mining" in use.
  - Therefore, the beam has to be sufficiently cooled before mining.
  - **How much we have to cool?:**

    MI demands the pbar longitudinal emittance to be ≤2 eVs/ 2.5 MHz bunch. Therefore, the beam has to be cooled in the Recycler <70 eVs before strip-mining shots to the Tevatron. If σ is not sufficiently small, and, do strip-mine, then we potentially cause poor coalescing efficiency in the Main Injector and Tevatron quench. ← Needs quantification

    ← Currently, with the electron cooling we are cooling the pbar beam in the Recycler to <70 eVs before Tevatron shots for beam intensity up to 450E10. So, strip-mining looks promising .
- Before any further LLRF requests we should quantify the emittance growths as a function of σ (Schottky) for different amount of cogg and barrier size. (see next page).
- If the above studies yield encouraging results then further improvements in LLRF morphing routines for strip mining is worth doing. Possibly we may benefit?

Study Plan

(Study request sent to Stan Pruss on 6/10/06)



Goal: Quantify the longitudinal emittance growth for "Strip-Mining"

Plan: Measure LE using Schottky and WCM before cogging and after cogging pbar beam in standard rectangular barrier buckets (6, 7)

Spacing between 6 and 7: 34, 288, 180, 108, 72 bkts

Initial Sigma ~ 1, 1,5, 2, 2.5, 3, 3.5, 4.

Cog Rate : slow,

Cog by: 36 to 288 bkts (about 3-4 points)

Beam Intensity ~ 40 E10 pbars

Total study time: ~ 10-20 min for each measurements.